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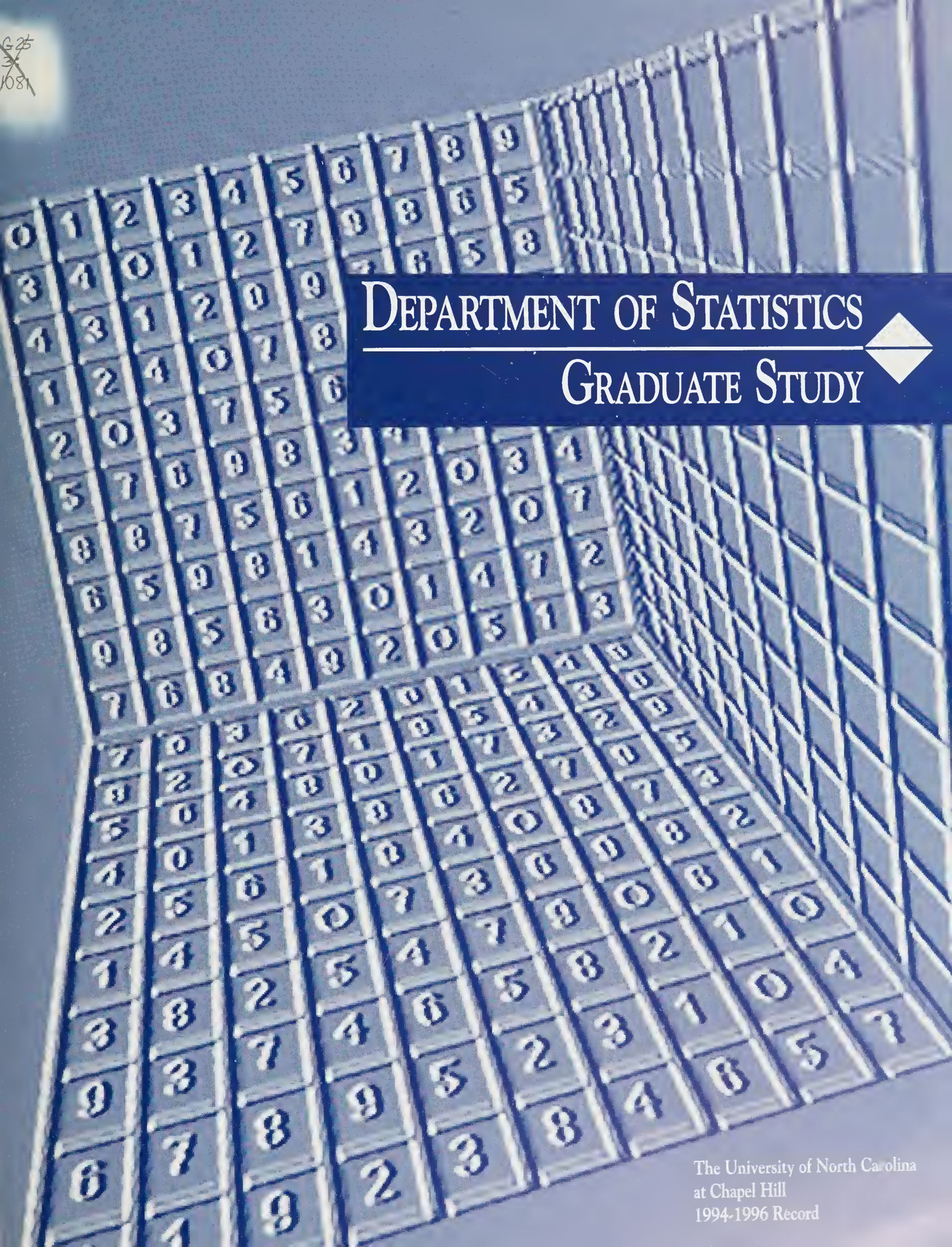

Department of Statistics

Graduate Study

The University of North Carolina
at Chapel Hill
1994-1996 Record

See page 28 for a description of the front cover image.

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Department of Statistics

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From the Chairman

Statistics is a vigorous and exciting field with continually expanding areas of application. Statistical methods apply in virtually every area of scientific inquiry from the hard sciences, such as physics and biology, to the social sciences and humanities. Employment opportunities are excellent in academia, business, industry, and government.

The Department of Statistics was established in 1946 and is one of the oldest in the world. It has a long tradition as a leader in theoretical statistics and probability. This tradition of excellence persists today through the department's strong research in such areas as stochastic processes and statistical inference. The strength of the graduate program has been a balanced development of statistical inference based on modern probability while also addressing important problems in applied areas.

Moreover, the Triangle area, which includes Raleigh, Durham, Chapel Hill, and the Research Triangle Park, is one of the premier areas of statistical education and research in the United States. Together, the Departments of Statistics and Biostatistics at UNC–Chapel Hill, the Statistics Department at North Carolina State University in Raleigh, and the Institute of Statistics and Decision Sciences at Duke University in Durham, include 85 full-time faculty and 260 graduate students. This high level of research activity in statistics is further enhanced by the National Institute of Statistical Sciences located in Research Triangle Park.

This booklet introduces you to graduate study in Statistics at The University of North Carolina at Chapel Hill. Here you will find background information about the department, details of the courses and graduate programs, descriptions of the faculty's research interests, and information on how to apply for the program and financial aid. As you read through this material, we hope you will sense the excitement we have about the field of statistics and the opportunities that await you in this outstanding research community!

From the Director of Graduate Admissions

Graduate training in this department will provide you with a thorough grounding in the theoretical background of the subject while introducing you to diverse areas of application. The opportunity to pursue applications is enhanced through contacts with other departments and research institutes such as Biostatistics, Mathematics, Operations Research, the Environmental Protection Agency, the National Institute of Environmental Health Sciences, and the National Institute of Statistical Sciences.

To enter the department you need first and foremost a strong mathematical background. The minimum requirements are two semesters of advanced calculus, one of linear algebra, and one semester each of calculus-based probability and statistics. Some applicants for the Ph.D. program have an M.S. degree in Statistics. The majority who do not have an M.S. degree receive one in the course of fulfilling the requirements for a Ph.D. The department's M.S. program is much smaller but there is a two-year program with an option to concentrate on either applied or theoretical statistics. The availability of financial aid varies from year to year but is typically in the range of five to eight awards per year. Competition for financial aid is fierce and to qualify you will need a strong undergraduate record and good scores in the Graduate Record Examination (including the advanced math examination). Students whose native language is not English also need to take the TOEFL exam.

Once in the department you will face a demanding sequence of first-year courses leading up to a comprehensive qualifying exam at the beginning of the second year. After clearing that hurdle you will have much more flexibility in choosing courses. By your third year you will have chosen a thesis adviser and topic, and by the end of the third year you should have taken your preliminary oral exam for the Ph.D. This exam requires a written report outlining the thesis topic and background literature. Students who pass are automatically awarded an M.S. degree. After that it's largely a matter of how long you take to finish the Ph.D. thesis. The typical program's length is five years, though ambitious students sometimes finish in four years or less.

Financial aid is mostly in the form of departmental (teaching and research) assistantships, which from the second year onward require teaching one elementary-level statistics course per year. Alternative opportunities for funding include employment in other campus departments and with local organizations in the Research Triangle Park such as the SAS Institute and the National Institute of Environmental Health Sciences.

If all this sounds like a lot of hard work, be assured that this is not the whole story! Chapel Hill boasts one of the most pleasant environments in the United States; accommodation is plentiful and relatively cheap, and transport is easy. The weather is mild all year. Social activities within the department include regular picnics and weekly sporting activities such as volleyball and soccer. In addition, there is all the social life you would expect within a campus of twenty-three thousand students.

I hope this booklet answers all the questions you have, but if not, do not hesitate to contact the department for further information.

From The Graduate Student Representative

I remember the difficult task of selecting a graduate school. I welcomed the advice of teachers, friends, and family. Many reminded me to consider quality of life at the school. Carolina's Statistics Department has a strong reputation among other top graduate departments throughout the nation. For me, however, much of its appeal came from the beauty of its surroundings and the affordability of student life.

The first year at Carolina is a difficult one. When you complete the year's course work you breath a sigh of relief and feel a great sense of accomplishment. The curriculum consists of eight courses that will give you a firm foundation in theory and applications. The qualifying exams are given in August just before the second year and are based entirely on the eight first-year courses.

The second year is completely different—the pace is much more relaxed. You still take six or seven courses (depending on whether you passed the qualifiers the first time) but the work required is quite different. The emphasis is on developing research abilities rather than on simply digesting material. If you need to retake the qualifiers, you do so in your second year. Once you pass them, you start thinking about choosing an adviser. During the second year you should talk to several faculty members about their work.

By the third year you have chosen an adviser and begun reading papers in your research area. You also finish your course work, making sure to fulfill the program requirements. By the end of the third year you should take the preliminary oral exam. This requires a written proposal that presents to your dissertation committee a literature review, the problem you intend to study, and an outline of how you intend to tackle it.

The fourth year centers almost exclusively on dissertation research. Many students devote a fifth year to research as well. You might also go to a professional meeting and give a talk on your work. After writing your dissertation you present a final oral defense that has two parts: a public talk and a private "grilling" by your committee. It is a tradition here that once you have passed your defense you throw a party for the entire department.

Outside of our individual hobbies and interests, we regularly play sports and socialize with people from the departments of Mathematics, Operations Research, and Biostatistics. Everyone here comes from a different background and has different ideas about the future. Through discussions with faculty and fellow students, I continue to form a basis for my research. So far, I've greatly enjoyed sharing my graduate experience with the group of people here at Carolina.

Introduction

The University of North Carolina at Chapel Hill

The University of North Carolina at Chapel Hill is one of the leading graduate research universities in the United States. Of the nearly twenty-three thousand students more than a quarter are in graduate programs. The University has been widely recognized for the quality of its 175 master's and 109 doctoral programs and for a faculty actively involved in research, scholarship, and creative work.

In a study published by the National Academy of Sciences (NAS) in 1982, Carolina was ranked as one of the foremost graduate research institutions in the nation. The academy concluded that Carolina was "the South's most admired teacher of science and mathematics." The statistics department was among the top-ranked departments in the nation and one of UNC–Chapel Hill's highest-ranked graduate programs. *The Public Ivys* (1985) by Richard Moll named Carolina as one of eight public universities in the United States equal in quality to the best Ivy League schools. Its superb library system contains more than three million volumes and is one of the best research libraries in the United States and Canada. Carolina's 687-acre central campus lies in the town of Chapel Hill in the Research Triangle area near the cities of Durham and Raleigh, which are homes for Duke University and North Carolina State University.

Research Triangle Park

Research Triangle Park, set in sixty-eight hundred acres of pinelands, is the largest among the 115 university-related research parks in the United States. More than thirty-four thousand people work in the park for the fifty-five companies and institutions there, which include IBM, Bell Northern, Burroughs Wellcome, Glaxo, the U.S. Environmental Protection Agency, the Research Triangle Institute, the National Institute of Environmental Health Sciences, the National Institute of Statistical Sciences, and the National Humanities Center. The wide spectrum of fields includes telecommunications, environmental sciences, pharmaceuticals, microelectronics, biotechnology, chemistry, toxicology, and statistics.

Chapel Hill

Chapel Hill can be at once invigorating and serene, contemporary and old-fashioned. Since its founding two hundred years ago, Chapel Hill's progressive spirit has grown with the times. Although it still calls itself a town, and some residents think of it as a village, Chapel Hill is a bustling community of thirty-eight thousand residents with a dazzling array of cultural and sporting activities. From Chapel Hill there is easy access to the Appalachian Mountains in the western part of the state, with abundant trails, ski slopes, folk art, and music and to the eastern coast with its beautiful beaches and historic areas including Kitty Hawk, Okracoke, and Wilmington.

Department of Statistics

The Department of Statistics was organized in 1946 with Harold Hotelling as its first chairman. Since 1948 more than two hundred Ph.D. degrees in Statistics have been awarded. Our graduates have assumed leadership positions in many important statistical organizations and have become chairs of several departments of Statistics here and abroad. Many professors at leading universities and senior statisticians in government and industry received their doctoral training in the Department of Statistics at Chapel Hill.

Much fundamental work in experimental design, coding theory, nonparametric inference, estimation and hypothesis testing, sequential analysis, renewal theory, and stochastic processes originated here. Together with the Department of Biostatistics at Chapel Hill and the Department of Statistics at North Carolina State University in Raleigh, the department publishes the Institute of Statistics Mimeo Series, which now includes more than twenty-three hundred titles and contains the first results of many of the fundamental lines of research in mathematical statistics as it exists today.

Center for Stochastic Processes

Also housed in the department is the Center for Stochastic Processes, whose members include three of the department's faculty and a number of visiting scholars each year. The center, begun in the early 1980s, is internationally recognized for its research program in the theory and application of stochastic processes. It has generated a vibrant research environment for interaction among department faculty, internationally recognized senior visitors, promising young researchers, and graduate students. The center's Technical Report Series now numbers more than four hundred titles.

Seminar series serve as a forum for the presentation and discussion of recent research and are considered an integral part of the graduate program and valuable for faculty and visitors as well.

The Statistics Colloquia meet regularly throughout the academic year. An average of twenty-five talks per year are given by visiting scholars and a few faculty members, and joint colloquia with Biostatistics and Mathematics are held periodically.

The Stochastic Processes Seminars are weekly talks by long- and short-term visitors to the center on current research in stochastic processes and related probability. They are given throughout the year with an average of thirty-five to forty talks per year.

The Hotelling Lectures are an annual event featuring three talks by an eminent guest speaker. The first lectures were given by David R. Cox in 1980 and in subsequent years by Herman Chernoff, Ole Barndorff-Nielsen, Frank Hampel, David Brillinger, David Kendall, Persi Diaconis, Pal Revesz, Willem van Zwet, C.R. Rao, Bradley Efron, Lucien LeCam, Peter Bickel, and Larry Shepp.

Location

The department is located primarily in Phillips Hall, together with the departments of Mathematics and Physics and Astronomy, with additional faculty offices across the street in New West. All graduate students are provided with offices, which are shared by one or two fellow students, either in Phillips Hall or in Smith Building.

Computing

A departmental network of Sun Sparc stations provides the opportunity for advanced computing in a Unix environment. The Graduate Student Computer Labs have nine PCs and five Sun workstations. Through the UNC Information Technology Office there is access to the campus mainframe, IBM 3090–170 computer, the VAX 6620 computer, a Convex C3840 mid-range supercomputer with emass data tower mass storage device. The North Carolina Supercomputing Center's CRAY Y–MPS/432 supercomputer is located in the Research Triangle Park and accessed through the high speed CONCERT network and the National Science Foundation supercomputers at the Pittsburgh Supercomputing Center and the Cornell National Supercomputer Facility.

Library

The Brauer Library, which serves the departments of Computer Science, Mathematics, Operations Research, Physics, and Statistics, is also located in Phillips Hall and maintains a collection of more than ninety thousand volumes, two thousand microfiche, one thousand technical reports, and about a thousand current journal subscriptions. The library's research collection in statistics and probability is excellent.

Interactions

The department has close connections with various centers of statistical activity in the area. The Department of Biostatistics at UNC–Chapel Hill offers a wide range of courses in applied statistics, which may be combined with the more theoretically oriented courses in the Department of Statistics to suit individual needs and interests. Other departments that provide opportunities for training in areas related to statistics include Mathematics, Operations Research, Computer Science,

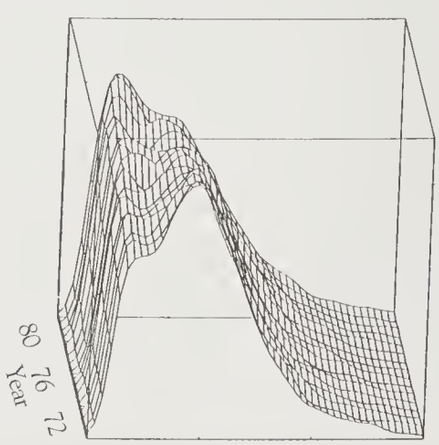
Statistics at work

Understanding Changes in Income Distributions

This surface shows how the distribution of family incomes in Great Britain changed in an important way during the years 1968–83. For each year a "kernel density estimate" shows the shape of the "income distribution." The curve is high for incomes that many families earn and low for incomes earned by relatively few. These sixteen curves are put one behind the other, in time order, to create a surface that allows easy visual understanding of how the distributions change over time.

Note that in 1968 there was a large "middle class" relative to the "lower class." But over time the relative proportions changed dramatically so that in 1983 the lower class made up a larger component of the population. This tool makes it clear that there was a major and important change in demographics during that period.

Family Income Distributions for Years 1968–1983



Economics, Environmental Sciences and Engineering, and the Psychometric Laboratory, all at Chapel Hill, the Department of Statistics in Raleigh, and the Institute of Statistics and Decision Sciences at Duke. In addition, various statistical research groups in the Research Triangle Park afford opportunities for scholarly work and summer employment. These include the Research Triangle Institute, the Environmental Protection Agency, the National Institute of Environmental Health Sciences, the National Institute of Statistical Sciences, and private businesses, such as SAS, Glaxo, and Burroughs Wellcome.

The Department of Biostatistics

One of eight departments in the School of Public Health, Biostatistics offers the M.S. and Ph.D. degrees, and statistics students often elect a supporting program in biostatistics. The departments of Statistics and Biostatistics maintain close ties: the Biostatistics chairman, Professor B. Margolin, is an adjunct professor in Statistics, and Biostatistics Cary C. Boshamer Professor P. K. Sen holds a joint appointment in the Department of Statistics. The biostatistics department offers a variety of applied courses of interest to our graduate students on topics such as categorical data, clinical trials, demography, sample survey methodology, statistics in epidemiology and environmental science, etc.

For further information on this program write to the Registrar, Department of Biostatistics, The University of North Carolina at Chapel Hill, Chapel Hill, NC 27599-7400.

Department of Mathematics

Also located in Phillips Hall, Mathematics has about thirty regular faculty members and offers the M.S. and Ph.D. degrees. Statistics students may elect a supporting program in mathematics. Courses are offered in the areas of algebra, analysis, geometry, topology, dynamical systems, combinatorics and applied mathematics. Of particular interest to some statistics students are courses in ergodic theory and dynamical systems. The departments of Mathematics and Statistics have close ties and two faculty members, Professors Ji and Kelly, hold joint appointments.

For further information write to: Director of Graduate Admissions, Department of Mathematics, The University of North Carolina at Chapel Hill, Chapel Hill, NC 27599-3250.

Department of Operations Research

M.S. and Ph.D. degrees are offered by Operations Research, and statistics students may elect a supporting program in this field. The study of Operations Research involves the application of diverse topics in mathematics and statistics to problems of resource allocation. Specialization is possible in theoretical areas (for example, mathematical programming or stochastic processes) or through specific applications (such as urban and environmental systems, population studies, or biological sciences).

For further information write to: Admissions Chairman, Department of Operations Research, The University of North Carolina at Chapel Hill, Chapel Hill, NC 27599-3180.

National Institute of Statistical Sciences

NISS was established in 1991 in Research Triangle Park by the Triangle Universities Consortium for Advanced Studies, comprised of UNC–Chapel Hill, Duke, North Carolina State University, the Research Triangle Institute, and the national statistics societies (American Statistical Association, Biometric Society, and Institute of Mathematical Statistics). Jerome Sacks is director and Alan Karr, who holds a joint appointment in the departments of Statistics and Biostatistics, is associate director.

NISS' mission is to ensure the vitality of the interaction between statistics and other fields—such as the physical, social and biological sciences, and engineering—by conducting programs of cutting-edge cross-disciplinary research involving statistics. To this end NISS identifies issues of national and global importance on which significant progress can be made by means of cross-disciplinary research involving statisticians and other scientists. These problems are characterized by social and economic significance, large scale and complexity, the size and high dimensionality of data sets, and the opportunity for research that constitutes substantive progress in statistics and other sciences. NISS then forms collaborative research teams of statisticians and other scientists, both senior and junior, with members from universities, government, and industry; secures the funding required to carry out research of the highest quality on these issues; and provides a research environment that fosters collaboration. NISS also communicates research results effectively and swiftly to multiple constituencies such as scientific and statistical communities, policy makers, the media, and the public; educates these constituencies regarding the interaction of statistics and other sciences; and transfers technology, for example, statistical methodologies and software, between statistics and other sciences and among scientific disciplines.

Current and prospective projects involve environmental modeling and monitoring, national assessment of educational programs, transportation (ranging from deterioration of concrete to travel demand forecasting to intelligent vehicle-highway systems), structural materials, large real-time software systems, and environmental indicators.

Graduate students in the Department of Statistics have the opportunity to be assigned as research assistants at NISS or for department faculty participating in NISS projects. This experience exposes them in depth to important application areas in which statistics is having real impact and to scientists from those areas with whom they interact closely. A research assistant assignment also provides a unique enrichment of the department's programs of course work and research.

Ph.D. PROGRAM

Students planning a career in teaching or research should work for the degree of Doctor of Philosophy. This requires at least three, but more usually, four to five years of full-time graduate work, predicated upon substantial undergraduate mathematical preparation. Research is an important part of the work of doctoral candidates.

The philosophy of the department is that its Ph.D. graduates should be broadly based in statistical theory and practice, and at the same time be able to conduct basic research in some special area of mathematical statistics or probability theory. The program's strength has been a balanced development of statistical inference based on modern probability while also addressing important problems in applied areas, with the aim of providing solid foundations for basic research, for teaching, and for statistical applications.

Ph.D. course work requires eighteen courses of three credit hours each: eight first-year courses, seven advanced courses, and three courses forming a "supporting program," two of which must be from outside the Department of Statistics. It is possible for some of these course requirements to be waived, but only on the grounds of prior knowledge and demonstrated competence of the subject material, and with the approval of the Curriculum Committee.

The first-year courses are listed below. They are designed to provide a broad base in probability and statistical theory and practice.

First-Year Courses

Fall

Stat 105 Elements of Statistical Analysis
Stat 112 Measure and Integration
Stat 129 Introduction to Stochastic Processes
Stat 134 Intermediate Statistical Theory I

Spring

Stat 132 Intermediate Probability
Stat 133 Introduction to Time Series Analysis
Stat 135 Intermediate Statistical Theory II
Stat 150 Analysis of Variance with Application to Experimental Designs

In the second and later years a student takes seven advanced courses in at least three of five areas of specialization listed below.

Advanced and Specialized Courses

Inference

Stat 220 Estimation, Hypothesis Testing, and Statistical Decision
Stat 221 Sequential Analysis
Stat 222 Nonparametric Inference: Rank-Based Methods
Stat 223 Nonparametric Inference: Smoothing Methods
Stat 224 Statistical Large Sample Theory
Stat 225 Subsampling Techniques
Stat 111 Methods of Mathematical Statistics

Probability and Stochastic Processes

Stat 231 Advanced Probability
Stat 232 Stochastic Processes
Stat 233 Time Series Analysis
Stat 234 ExtremeValue Theory
Stat 235 Point Processes
Stat 236 Stochastic Analysis
Stat 111 Methods of Mathematical Statistics

Design of Experiments

Stat 210 Design and Analysis of Experiments
Stat 211 Special Topics in the Design of Experiments
Stat 212 Combinatorial Problems of the Design of Experiments
Stat 253 Error Correcting Codes

Multivariate Analysis

Stat 260 Multivariate Analysis
Stat 261 Advanced Parametric Multivariate Analysis

Communication Theory

Stat 142 Introduction to Estimation and Detection Theory
Stat 232 Stochastic Processes
Stat 252 Information Theory
Stat 253 Error Correcting Codes
Stat 111 Methods of Mathematical Statistics

Applied Statistics Courses

Stat 205 Statistical Quality Improvement
Stat 302 Seminars in: Data Analysis, Applied Statistics, Statistical Computing, and Statistical Consulting

At least two areas must be represented by two or more courses each. Typically, four courses are taken in the student's major area, two are in another area, and the seventh course is in a third area. Possible areas of specialization cover the spectrum of probability and statistical inference, including design of experiments, multivariate analysis, nonparametrics, stochastic processes, and communication theory. A great deal of exciting work is in progress in various areas of statistical inference, in stochastic modeling and analysis, and in their interplay. The availability of powerful computing capabilities has opened up new areas of research and provided new approaches across the entire field. Much of the work is stimulated by a demand for innovative solutions to practical problems that arise throughout the social and natural sciences and engineering: industrial experimentation, imaging, pattern recognition, medical research, clinical trials, data transmission and compression, econometrics, geology, neurophysiology, mathematical physics, engineering, and environmental applications. Statisticians with wide interests and expertise in these areas are in high demand from pharmaceutical and engineering companies as well as from research organizations and institutes.

Typical advanced courses in the five areas are listed below. Other courses may be added in various areas with approval of the Curriculum Committee.

Examinations

Doctoral students must first pass the basic written examinations, which cover the material in the first-year courses. These consist of three parts, each at least four hours long. Parts I (112, 132, 133, 134) and II (129, 135,

150) are closed book, while for Part III (105, 135, 150) class notes can be used. They are usually given early in the fall semester of the second year.

Students are expected to complete the preliminary oral examination no later than the end of the sixth semester. This is based on an essay including a description of the proposed dissertation topic, a review of the literature, and a bibliography related to the proposed research. At this examination the student describes the thesis proposal and answers questions on it and on the literature reviewed. A Ph.D. student who has passed this oral examination and who wishes to obtain an M.S. degree may do so without having to take the final oral examination normally required for the M.S.

When ready, the candidate submits the dissertation to the members of his/her committee. At the final oral examination the candidate presents the dissertation research and conclusions and answers questions.

Recent Ph.D.s, Dissertation Topics, and Advisers

David Baldwin (1992)
Topics in the theory of stochastic processes taking values in the dual of a countably Hilbertian nuclear space. Adviser: G. Kallianpur

Kamal Benchekroun (1993)
Association-balanced arrays with applications to experimental designs. Adviser: I.M. Chakravarti

Jason Brown (1993)
A finite sampling plan, central limit theorem and bootstrap algorithm for homogeneous and isotropic random field on the e-dimensional sphere. Adviser: E. Carlstein

Amarjit Budhiraja (1994)
Multiple stochastic integrals with applications to asymptotic statistics and nonlinear filtering. Adviser: G. Kallianpur

Ming-Yen Cheng (1994)
Curve estimation with boundary considerations. Adviser: J.S. Marron

Shubhabrata Das (1993)
Restricted canonical correlations. Adviser: P.K. Sen

Steven Garren (1994)
Parametric and nonparametric modeling of data using sampling algorithms. Adviser: R.L. Smith

Zhan-Qian Lu (1994)
Estimating Lyapunov exponents in chaotic time series with locally weighted regression. Adviser: R.L. Smith

Robert Lund (1993)
Some limiting and convergence rate results in the theory of dams. Adviser: W.L. Smith

Lynne Seymour (1993)
Selection procedures for Gibbs-Markov random field texture models. Adviser: C. Ji

Michael Sherman (1992)
Subsampling and asymptotic normality for a general statistic from a random field. Adviser: E. Carlstein

Seokhoon Yun (1994)
Extremes and threshold exceedances in higher order Markov chains with applications to ground-level ozone. Adviser: R.L. Smith

Jie Xiong (1992)
Nuclear space-valued stochastic differential equations driven by Poisson random measures. Adviser: G. Kallianpur

Ming Zhang (1993)
Adaptive statistical analysis of repeated measurements designs. Adviser: P.K. Sen

Typical Doctoral Program

First Year

Fall Courses: 105, 112, 129, 134
Spring Courses: 132, 133, 135, 150

Duties:
Assist instructor with undergraduate course each semester

Other:
Prepare for August written exams

Second Year

Courses:
Seven advanced courses

Duties:
Teach undergraduate course one semester, assist instructor one semester

Other:
Choose dissertation adviser

Third Year

Courses:
Three advanced courses

Research:
Half-time

Duties:
Teach undergraduate course one semester, assist instructor one semester

Other:
Preliminary Oral Examination

Fourth and Fifth Years

Research:
Full-time

Duties:
Teach undergraduate course one semester, assist instructor one semester

Other:
Final Oral Examination

M.S. Program

Though the M.S. program is small, the department provides a wide variety of courses leading to the master's degree. The basic philosophy is that this program should provide a broad training in statistical theory and practice, with the student being able to specialize in either applied or theoretical areas. Students who have completed the master's program have had little difficulty in finding jobs in industry or government. Many have found the M.S. in Statistics a beneficial adjunct to a Ph.D. degree in another field of study.

The M.S. degree requires satisfactory completion of thirty semester hours of course work. There are two options: Applied Statistics and Mathematical Statistics. Each consists of a core of required courses, broadening courses in statistics, and two courses to be taken outside the department. Four semesters are regarded as normal time for the completion of all requirements for the master's degree.

Profile

Li-Shan Huang

I came to Chapel Hill two months after I graduated from National Central University in Taiwan. My first year here was truly a puzzling and different experience. It was hard to keep myself from thinking about home in Taiwan and to study hard for the stressful first-year courses.

After the comprehensive exams, I had a little more time to look at the world around me. Second-year students are usually assigned to teach a basic statistics course. I was really nervous about teaching in the beginning, afraid of being laughed at because my English has an accent. I spent time reading class notes aloud and explaining them to myself. Soon, there were faces of students saying "I understand." I will never forget the unexpected support from the students for my first time teaching in English.

I am now working on my dissertation, and recently as a research assistant for the National Institute for Statistical Sciences (NISS) and for two professors in the department. Mostly, the assistantship focuses on analyzing ozone data sets provided to NISS by the Environmental Protection Agency. We have studied the meteorological effect on ozone levels in the Chicago area and now are working on data from Philadelphia and Houston. I was immersed in an experience that allowed me to gain a sense of data analysis for industry. Moreover, by assisting professors, I gain much knowledge from them that often cannot be found in books.

The years have been highly rewarding and inspiring not only in academic work but also in the touch of people from different countries and cultures. Still, even now I can be puzzled, and sometimes even stunned by things I have never seen before. But now I know that they are just lessons to broaden my scope. I am glad that I made the right choice to come to Chapel Hill.

Applied Statistics Option

The required courses are:

Track 1

Stat 126 Introduction to Probability (is a prerequisite)
Stat 104 (Bios 164). Sample Survey Methodology
Stat 105 Elements of Statistical Analysis
Stat 127 Mathematical Statistics
Stat 129 Introduction to Stochastic Processes
Stat 133 Introduction to Time Series Analysis
Stat 160 (Bios 166). Applied Multivariate Analysis I

Track 2

Stat 104 (Bios 164). Sample Survey Methodology
Stat 105 Elements of Statistical Analysis
Stat 133 Introduction to Time Series Analysis
Stat 134 Intermediate Statistical Theory I
Stat 135 Intermediate Statistical Theory II
Stat 160 (Bios 166). Applied Multivariate Analysis I

The students will also be required to take two broadening courses in statistics, which may be selected from:

Stat 107 (Math 162). Actuarial Math II
Stat 129 Introduction to Stochastic Processes
Stat 150 Analysis of Variance with application to Experimental Designs
Stat 210 Design and Analysis of Experiments
Stat 260 Multivariate analysis

Other courses may be substituted with the permission of the Curriculum Committee.

Mathematical Statistics Option

The required courses are:

Stat 105 Elements of Statistical Analysis
Stat 129 Introduction to Stochastic Processes
Stat 134 Intermediate Statistical Theory I
Stat 135 Intermediate Statistical Theory II
Stat 150 Analysis of Variance with Application to Experimental Designs

The broadening course work consists of three additional courses in statistics chosen from either the list of broadening courses in the Applied Statistics option or 112, 132 only as a sequence; any 200-level statistics course;

other courses approved by the Curriculum Committee.

Examinations

Students in the Applied Statistics option are expected to be familiar with a formal programming language and must either pass (at the M.S. level) Part III of the doctoral written examinations or an examination covering courses 105, 127, and one of 133 or 150. Students in the Mathematical Statistics option must pass a written examination covering 129, 134, 135, and 150.

All M.S. students must write a short thesis or an essay. This is normally done during the student's fourth semester. The topic and scope of the work are decided in consultation with, and with the approval of, the student's adviser. Students in the Mathematical Statistics option should write a thesis or essay that demonstrates capability for research or understanding of recent research papers in some area of statistics; those choosing the Applied Statistics option should write an essay or thesis involving the analysis of data.

The final oral examination is given when a student's course work and thesis or essay are complete. The final oral examination is waived for a student who has passed a Ph.D. preliminary oral examination in statistics.

Admission, Finances, Duties, and Deadlines

Prerequisites

Admission to the Graduate School is necessarily a selective process and only applicants with academic records of high quality should seek admission. The minimal requirement is a Bachelor of Arts or Bachelor of Science degree from an accredited college or university in this country with a B average or better, or its equivalent based on a four-year curriculum in a foreign institution.

The department places strong emphasis on the mathematical theory of probability and statistics and thus sound mathematical preparation is an essential prerequisite for admission. An applicant's mathematical background should include a one-year course in advanced (multivariable) calculus or real analysis, at least a one-semester course in matrix algebra, and calculus-based courses in probability and statistics.

Procedures

Application forms for admission and/or financial aid may be obtained by writing to:

The Graduate School
200 Bynum Hall
The University of North Carolina
Chapel Hill, NC 27599-4010

A complete application must include the following:

1. The completed application forms in duplicate.

2. Two official transcripts of all previous undergraduate and graduate work.

3. Three references (forms provided) from people familiar with the applicant's academic achievement and potential.

4. A nonrefundable application fee of $55.00. A successful applicant reserves his/her place by the payment of the nonrefundable deposit, which is credited toward the first semester's tuition.

5. Test scores for both the Aptitude and Advanced Mathematics Graduate Examination. This examination is given at regular intervals at most universities in this country and in many countries abroad. Applicants for financial aid should take the examination no later than October for admission the following fall semester. (Under certain exceptional circumstances the department may waive this requirement.)

6. Students whose native language is not English are required to take the Test of English as a Foreign Language examination (TOEFL) administered by the Educational Testing Service. The required minimum total score on the TOEFL test is 550. (Again, in exceptional circumstances this requirement may be waived.)

In addition to the above, the Department of Statistics strongly recommends that applicants submit the following material:

7. Brief course descriptions, including text titles where applicable, of all previous undergraduate and graduate courses in (a) probability and statistics, (b) mathematics above the level of elementary calculus, and (c) other courses of a mathematical nature, such as computer science, mathematical physics, etc.

8. A statement of areas of interest in probability and statistics, and of career goals.

Financial Assistance

More than 90 percent of Ph.D. graduate students in the statistics department receive financial aid. The department offers a number of departmental assistantships each year to students who enter the Ph.D. program. These assistantships are renewable each academic year, contingent upon satisfactory progress toward a degree and availability of funds. Normally, assistantships are not awarded to a student beyond the fifth academic year. The stipend for 1994–5 is $10,000. In addition there are several Merit Assistantships of $11,000 for incoming students. Exceptionally strong applicants are nominated by the department for University Fellowships administered through the Graduate School. Competition for these awards is University wide, and the 1994–5 stipend is $14,000 plus tuition and fees. Students are also urged to apply for fellowships available through national, regional, and foundation sources.

Minority Presence Awards

Under the Board of Governors general Minority Presence Grant Program, African American students may be eligible for special financial assistance if they are residents of North Carolina, enrolled for at least three

hours of degree-credit course work, and demonstrate financial need.

The Minority Presence Grant Program for Doctoral Study provides stipends of $9,000 for the academic year with an option of additional support for study in the summer session for African American residents of North Carolina who are selected to participate. Recipients must be full-time students pursuing doctoral degrees at The University of North Carolina at Chapel Hill.

Tuition and Fees

Full-time students who have been awarded assistantships are eligible for a special tuition rate, currently identical to the in-state rate of $1,446 per academic year for both tuition and fees. The out-of-state rate for 1993–4 was $8,488. Entitlement to the special rate is forfeited if a student fails to complete a full semester. Tuition and fees are due at registration; accounts not paid in full by the last day of registration are subject to a late payment fee and possible cancellation of the student's enrollment. These rates are determined by the state legislature and may change each year.

Duties

First-year students on assistantships are not required to teach. Instead they are assigned to assist one of the instructors with an undergraduate statistics course. Typically, this includes helping undergraduate students with problem solving, holding periodic tutorials, and grading homework. Such assignments are carefully controlled so that a full-time course load can be pursued and normally do not require more than six to eight hours per week.

After the first year, qualified students on assistantships teach one elementary-level statistics course per year. The average class size is thirty-five students and assistance is provided for grading homework. Student-taught sections are monitored by the Director of Undergraduate Studies and teaching assistants (TAs) have access to advice, training, and teaching aids from the University's Center for Teaching and Learning. The department awards two teaching prizes each year.

Deadlines

The Department of Statistics normally admits students in the fall semester. The deadlines for application for admission in the fall semester are as follows:

a) 1 February for admission and financial aid.
b) 1 April for admission without aid if space is available.

Further Information

The Department of Statistics welcomes applicants for admission and aid from members of minorities. Admission and aid are awarded without consideration of race, religion, sex, ethnic origin, or disability.

For further information write or call:

Graduate Admissions
Department of Statistics
The University of North Carolina
Chapel Hill, NC 27599-3260
919/ 962-2307

Profile

James MacDougall

Toward the end of my undergraduate studies I decided to continue my education and go for an M.S. in Statistics. While working toward my M.S. at the University of Massachusetts, the academicians [I met] and jobs I held increased my desire to continue my education. When I discussed different doctoral programs with my professors, UNC–Chapel Hill continually came up as one of the best theoretical statistics departments in the nation.

My decision to come to UNC–Chapel Hill was based on many things. The department's reputation is excellent but other factors also affected my decision. I decided to live outside of New England but I still wanted to live in an area with economic opportunities. The proximity of Research Triangle Park, SAS, and other industries enhanced my desire to come here.

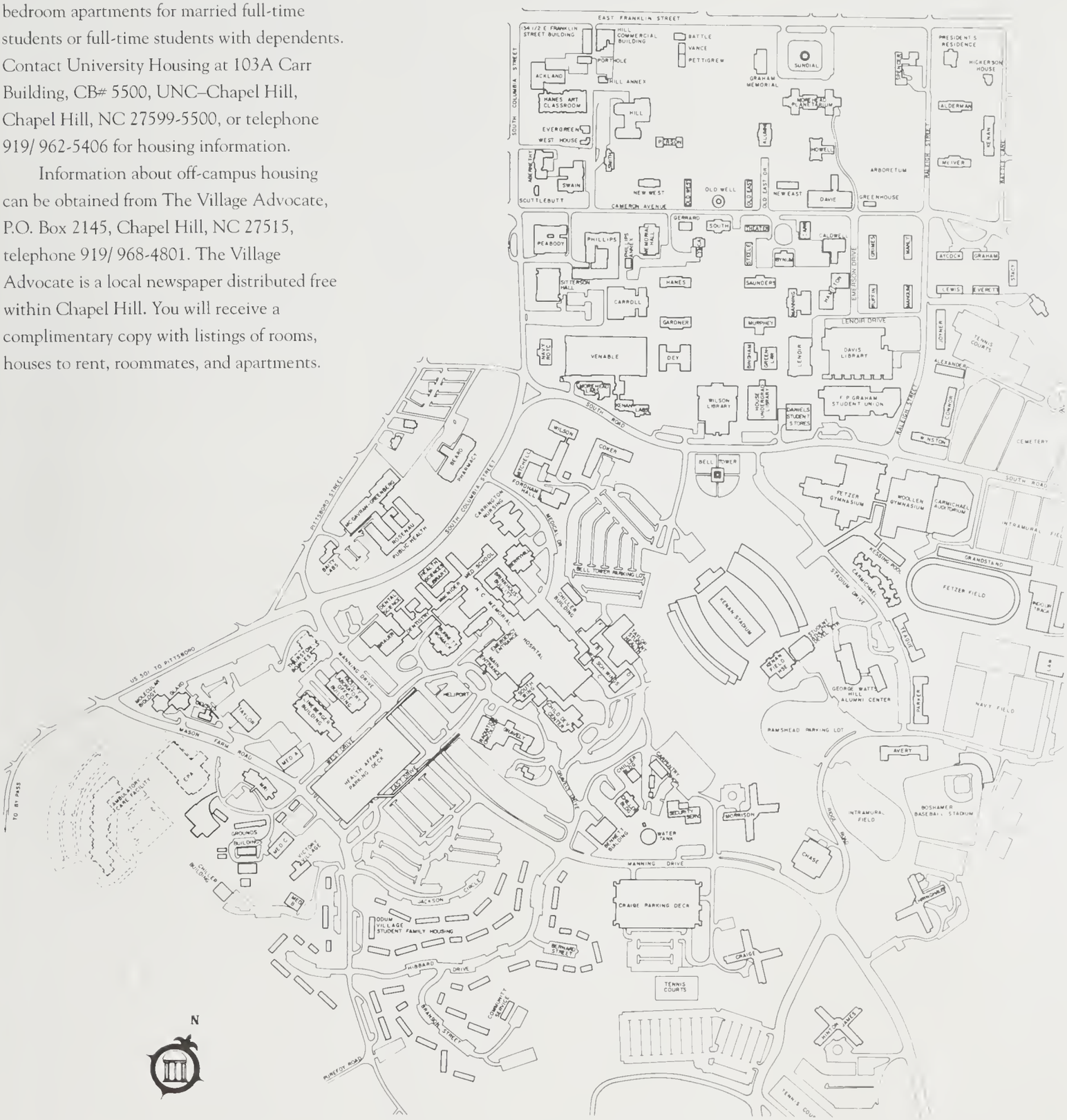
The first year has been exciting. The course work has kept me very busy but it has been a rewarding experience. A great camaraderie has been formed among myself and the other first-year students. Working together with them has been one of the best aspects of my time spent here so far.

North Carolina is a beautiful state; there are many ways to relax both in and outside the department. Volleyball, softball, and other recreational sports are a part of the weekly agenda within the department. In general, I have found the quality of life here to be superb and I am looking forward to the coming years.

Housing

Craige Residence Hall houses single graduate students and Odum Village has one- and two-bedroom apartments for married full-time students or full-time students with dependents. Contact University Housing at 103A Carr Building, CB# 5500, UNC–Chapel Hill, Chapel Hill, NC 27599-5500, or telephone 919/ 962-5406 for housing information.

Information about off-campus housing can be obtained from The Village Advocate, P.O. Box 2145, Chapel Hill, NC 27515, telephone 919/ 968-4801. The Village Advocate is a local newspaper distributed free within Chapel Hill. You will receive a complimentary copy with listings of rooms, houses to rent, roommates, and apartments.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MEDICAL DR
BELL TOWER PARKING LOT
CARRINGTON NURSING
BEARD PHARMACY
BATTLE
VANCE
PETTIGREW
PORTHOLE
HILL ANNEX
HILL
MCCAIN
ACKLAND
HANES ART CLASSROOM
EVERGREEN
WEST HOUSE
SCUTTLEBUTT
SWAIN
OLD EAST
OLD WEST
ALUMNI
SMITH
PARSON
HOWELL
HILL COMMERCIAL BUILDING
34 1/2 E FRANKLIN STREET BUILDING
PETZER GYMNASIUM
WOOLLEN GYMNASIUM
CARMICHAEL AUDITORIUM
GRANDSTAND
FETZER FIELD
INTRAMURAL FIELD
KENAN STADIUM
STADIUM DRIVE
RESTING POOL
CARMICHAEL
FETZER
GEORGE WATTS HILL ALUMNI CENTER
RAMSHEAD PARKING LOT
NAVY FIELD
BOSHAMER BASEBALL STADIUM
AVERY
MORRISON
CHASE
CRAIGE PARKING DECK
CRAIGE
TENNIS COURTS
WATER TANK
HOSPITAL
MEMORIAL HOSPITAL
MANNING DRIVE
HEALTH AFFAIRS PARKING DECK
HELIPORT
NORTH CAROLINA MEMORIAL HOSPITAL
CHILLER BUILDING
BIOMEDICAL RESEARCH BUILDING
MACNIDER BUILDING
BRAUER HALL
MARK HOLLAND BUILDING
BURNETT-WOODHOUSE BUILDING
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DENTAL SCIENCES BUILDING
DENTAL BUILDING
SCHOOL OF PUBLIC HEALTH
NORTH CAROLINA MEMORIAL HOSPITAL
MANNING DRIVE PARKING DECK
MANNING DRIVE OFFICE BUILDING
MANNING DRIVE BUILDING
BOLIN-KESSING BUILDING
TAYLOR
DAVIES
WILSON BUILDING
BEARD
PHARMACY
NORTH CAROLINA MEMORIAL HOSPITAL
SCHOOL OF PUBLIC HEALTH
BATTLE LABS
MEDICAL SCHOOL
MEDICAL SCIENCES BUILDING
MEDICAL SCIENCES RESEARCH BUILDING

Courses[1, 2]

Graduate and Advanced Undergraduate

101-Statistical Methods I (Biostatistics 150)
Prerequisite, integral calculus. Basic probability, descriptive statistics, introduction to statistical inference including estimation, hypothesis testing, simple linear regression, nonparametric tests, contingency tables. Use of statistical computer packages. Fall and spring. Chakravarti, Fan, Marron, Nobel. (3).

102-Statistical Methods II
Prerequisite, Statistics 101. Linear regression, experimental designs, multivariate analysis, statistical computer packages. Spring. Chakravarti, Nobel. (3).

104-Sample Survey Methodology (Biostatistics 164)
Prerequisite, Statistics 102 or equivalent. Principles and methods associated with survey sampling, including simple random sampling, stratified sampling and cluster sampling. Questionnaire design, problems of nonresponse, sources of nonsampling errors. Design, execution, and analysis of an actual survey. Spring. Kalsbeek. (3).

107-Actuarial Mathematics II (Mathematics 162)
Prerequisites, Mathematics 161, Statistics 126. The theory introduced in Actuarial Mathematics I is expanded to encompass more complex models of financial transactions and risks. Spring. Staff. (3).

126-Introduction to Probability (Mathematics 146)
Prerequisite, Mathematics 33. Introduction to mathematical theory of probability covering random variables, moments, binomial, Poisson, normal and related distributions, generating functions, sums and sequences of random variables, and statistical applications. Fall and spring. Kelly, Nobel, W. Smith. (3).

127-Mathematical Statistics
Prerequisite, Statistics 126 or equivalent. Functions of random samples and their probability distributions; introductory theory of point and interval estimation and of hypothesis testing; elementary decision theory. Fall and spring. Carlstein, Fan, Marron, Nobel, Simons. (3).

Graduate

105-Elements of Statistical Analysis
Prerequisite, permission of instructor. Various topics in statistical methods, including applied regression analysis, analysis of simple experimental designs, data analysis, discrete multivariate data. Fall. Carlstein, Nobel, R. Smith. (3).

111-Methods of Mathematical Statistics
Prerequisite, advanced calculus. Introductory treatment of special mathematical techniques of particular importance in probability and statistics, including complex variables, Fourier and Laplace transforms, elements of finite difference equations. Staff. (3).

112-Measure and Integration
Prerequisite, advanced calculus. Lebesgue and abstract measure and integration, convergence theorems, differentiation. Radon-Nikodym theorem, product measures. Fubini theorems. Lp spaces. Fall. Baker, Cambanis, Kallianpur, Leadbetter. (3).

129-Introduction to Stochastic Processes
Prerequisites for nonstatistics majors, Statistics 126 and permission of instructor. Elementary theory and application of random process models, recurrent events, random walks. Markov chains. Poisson processes, birth-and-death processes, queuing processes, branching processes, Brownian motion, stationary processes. Fall. Leadbetter, W. Smith. (3).

132-Intermediate Probability (Mathematics 195)
Prerequisite, Statistics 112 or permission of instructor. Foundations of probability. Basic classical theorems. Modes of probabilistic convergence. Central limit problem. Generating functions, characteristic functions. Conditional probability and expectation. Spring. Cambanis, Kelly, Kallianpur, Leadbetter. (3).

133-Introduction to Time Series Analysis
Prerequisite, Statistics 126. Topics chosen from time series data analysis. Fitting parametric models, such as autoregressive models to time series. Spectral analysis. Filtering. Spring. Cambanis, Leadbetter, Simons. (3).

134-Intermediate Statistical Theory I
Prerequisite, two semesters of advanced calculus. Fundamentals of probability and distribution theory including axiomatic treatment of probability, independence, random variables, characteristic functions, convergence and approximation, common distributions. Fall. Cambanis, Fan, Nobel, Simons. (3).

135-Intermediate Statistical Theory II
Prerequisite, Statistics 134 or equivalent. Fundamentals of statistical inference including sufficient statistics, estimation, hypothesis testing, decision theory, various classical tests. Linear estimation and analysis of variance and regression are largely excluded (see Statistics 150). Spring. Ji, Marron, Nobel, Simons. (3).

142-Introduction to Estimation and Detection Theory
Prerequisites, Statistics 129, 134. The Wiener-Kolmogorov and the Kalman-Bucy filtering theories. Modulation theory. Basic problems of detection theory. Cambanis. (3).

[1] Courses listed are those that have been taught in recent years.
[2] Advanced courses are taught in alternative years depending on demand.

150-Analysis of Variance With Application to Experimental Designs
Corequisite, Statistics 135. Linear estimation. Gauss-Markov theorem. Sums of squares. Analysis of variance and simple factorial designs. Intrablock analysis of incomplete block designs. Balanced, lattice, and Latin square designs. Spring. Chakravarti, Marron. (3).

156-Combinatorial Mathematics (Mathematics 148)
Prerequisite, Mathematics 81 or equivalent, or permission of the instructor. Topics chosen from generating functions, Polya's theory of counting, partial orderings and incidence algebras, principle of inclusion-exclusion, Moebius inversion, combinatorial problems in physics and other branches of science. Fall. Brylawski. (3).

158-Introduction to Graph Theory (Mathematics 149)
Prerequisite, Mathematics 116, 137, or 147. Basic concepts of directed and undirected graphs, partitions and distances in graphs. Planar and nonplanar graphs. Matrix representation of graphs, network flows, applications of graph theory. Staff. (3).

160-Applied Multivariate Analysis I (Biostatistics 166)
Prerequisite, Statistics 102. Application of multivariate techniques with emphasis on the use of computer programs. Multivariate analysis of variance, multivariate multiple regression, weighted least squares, principal component analysis, canonical correlation, and related techniques. Spring. Muller. (3).

171-Introduction to Nonparametric Statistics (Biostatistics 256)
Prerequisite, Biostatistics 160 or equivalent. Theory and application of nonparametric methods for various problems in statistical analysis. Includes procedures based on randomization, ranks, and U-statistics. A knowledge of elementary computer programming is assumed. Fall. Bangdiwala. (3).

181-Deterministic Models in Operations Research
(Mathematics 151, Operations Research 181) Prerequisite, Mathematics 147. Linear, integer, nonlinear and dynamic programming, classical optimization problems, network theory. Fall. Provan, Tolle. (3).

Advanced Graduate

205-Statistical Quality Improvement
Prerequisites, Statistics 105, 135, 150. Methods for quality improvement through process control, graphical methods, designed experimentation. Shewhart charts, cusum schemes, methods for autocorrelated multivariate process data, process capability analysis, factorial and response surface designs, attribute sampling. Rodriguez. (3).

Profile

Robert Derr

I was a displaced Minnesotan getting a master's in mathematics from Indiana University when I took my first statistics course. I enjoyed applications so I took a job at the Bureau of Labor Statistics in Washington, D.C. with the intention of returning to graduate school. After several years of applied statistics, applied logic, and lengthy management meetings, I felt it was time to get a solid and broad background in the theory. With D.C., the National Institute of Statistical Sciences, and the Research Triangle Park nearby, UNC–Chapel Hill suited my needs.

The first semester started out rather easy but then the workload increased and rarely let up. Four graduate courses in a semester make undergraduate work seem trivial. Readjusting to full-time study was difficult; I still feel like I waste too much time and don't study as intensely as I could.

There are plenty of opportunities to keep a somewhat balanced life, though. I took up Tai Chi to relax before the comps, and I use UNC's new weight room. I also join other grad students to play softball, touch football, volleyball, pool, and poker. There are also UNC football and basketball games that must be watched.

I have finished my second year now and it will soon be time to decide on a dissertation adviser. I am teaching a class and since it takes much longer to prepare a statistics lecture than I thought, this has given me a useful excuse for putting off my decision about what topics to concentrate on!

210-Design and Analysis of Experiments
Prerequisites, Statistics 105 and 150. The principles of the design and analysis of experiments. Latin and Graeco-Latin squares, incomplete block designs, factorial experiments. Confounding, fractional factorials, split plots, missing plots. Interblock analysis, covariance analysis. Response surfaces. Chakravarti. (3).

211-Special Topics in the Design of Experiments
Prerequisite, Statistics 150. Factorial experiments, construction and analysis of symmetrical, mixed, and fractional factorial designs. Orthogonal and balanced arrays. Response surface methodology. Mixture and screening designs. Optimality of designs. Recent developments. Chakravarti. (3).

212-Combinatorial Problems of the Design of Experiments
Prerequisite, Statistics 150. Finite groups, fields, and geometries. Difference sets. Orthogonal Latin squares, orthogonal arrays, balanced and partially balanced incomplete block designs. Algebras of association schemes and relations. Randomization, orthogonal designs, general balance, and strata. Chakravarti. (3).

220-Estimation, Hypothesis Testing, and Statistical Decision
Prerequisites, Statistics 132, 135. Bayes procedures for estimation and testing. Minimax procedures. Unbiased estimators. Unbiased tests and similar tests. Invariant procedures. Sufficient statistics. Confidence sets. Large sample theory. Statistical decision theory. Simons. (3).

221-Sequential Analysis
Prerequisites, Statistics 132 and 135. Hypothesis testing and estimation when the sample size depends on the observations. Sequential probability ratio tests. Sequential design of experiments. Optimal stopping. Stochastic approximation. Simons. (3).

222-Nonparametric Inference: Rank-Based Methods
Prerequisites, Statistics 132, 135. Estimation and testing when the functional form of the population distribution is unknown. Rank, sign, and permutation tests. Optimum nonparametric tests and estimators, including simple multivariate problems. Sen. (3).

223-Nonparametric Inference: Smoothing Methods
Prerequisites, Statistics 132, 135. Density and regression estimation when no parametric model is assumed. Kernel, spline, and orthogonal series methods. Emphasis on analysis of the smoothing problem and data based smoothing parameter selectors. Marron. (3).

224-Statistical Large Sample Theory
Prerequisites: Statistics 132, 135. Asymptotically efficient estimators; maximum likelihood estimators. Asymptotically optimal tests; likelihood ratio tests. Simons. (3).

225-Subsampling Techniques
Prerequisite, Statistics 135. Basic subsampling concepts: replicates, empirical c.d.f., U-statistics. Subsampling for i.i.d. data: jackknife, typical-values, bootstrap. Subsampling for dependent or nonidentically distributed data: blockwise and other methods. Carlstein. (3).

231-Advanced Probability
Prerequisites, Statistics 112, 132. Advanced theoretical course covering topics selected from weak convergence theory, central limit theorems, laws of large numbers, stable laws, random walks, martingales. Kallianpur, W. Smith. (3).

232-Stochastic Processes
Prerequisites, Statistics 112, 132. Advanced theoretical course including topics selected from foundations of stochastic processes, renewal processes, stationary processes, Markov processes, martingales, point processes. Cambanis. (3).

233-Time Series Analysis
Prerequisites, Statistics 112, 132. Analysis of time series data by means of particular models such as autoregressive and moving average schemes. Spectral theory for stationary processes and associated methods for inference. Stationarity testing. Leadbetter. (3).

234-Extreme Value Theory
Prerequisites, Statistics 132 and 134. Classical asymptotic distributional theory for maxima and order statistics from i.i.d. sequences, including extremal types theorem, domains of attraction, Poisson properties of high level exceedances. Extremal properties of stationary stochastic sequences and continuous time processes. Leadbetter. (3).

235-Point Processes
Prerequisite, Statistics 132. Random measures and point processes on general spaces, general Poisson and related processes, regularity, compounding. Point processes on the real line, stationarity and Palm distributions, Palm-Khintchine formulae. Convergence of point processes and related topics. Leadbetter. (3).

236-Stochastic Analysis
Prerequisite, Statistics 112, 132, or permission of the instructor. Advanced course covering topics selected from semimartingale theory, stochastic integrals, homogeneous chaos expansions, stochastic differential equations, Malliavin calculus, infinite dimensional processes, functional central limit theorems, Feynman-Kac formula, Feynman integral. Applications to filtering theory, infinite particle systems, quantum mechanics, and stochastic models in neurophysiology. Kallianpur. (3).

252-Information Theory
Prerequisite, Statistics 134. Transmission of information, entropy, message ensembles, discrete sources, transmission channels, and channel encoding and decoding for discrete channels. Chakravarti. (3).

253-Error Correcting Codes
Prerequisite, Statistics 212, or permission of the instructor. Linear codes and their error-correcting capabilities. Hamming codes, Reed-Muller codes, cyclic codes, Bose-Chaudhuri codes, Goppa codes. Burst error corrections. Majority logic decoding. Chakravarti. (3).

260-Multivariate Analysis
Prerequisites, Statistics 135 and matrices. Multivariate normal distributions. Related distributions. Tests and confidence intervals. Multivariate analysis of variance, covariance, and regression. Association between subsets of a multivariate normal set. Theory of discriminant, canonical, and factor analysis. Chakravarti. (3).

261-Advanced Parametric Multivariate Analysis
Prerequisite, Statistics 260. Distribution problems involved in the normal theory analysis of general multivariate linear models including the growth curves. Roy's union-intersection principle and its role in multivariate analysis. An introduction to zonal polynomials and orthogonal groups. Chakravarti, Sen. (3).

262-Nonparametric Multivariate Analysis
Prerequisite, Statistics 222. Nonparametric MANOVA. Large sample properties of the tests and estimates. Robust procedures in general linear models including the growth curves. Nonparametric classification problems. Sen. (3).

300-Seminar in Statistical Literature (1)
Prerequisite, Statistics 135. (1).

302-Seminar in Statistical Data Analysis
Prerequisite, Statistics 105. (Var.)

310, 311-Seminar in Theoretical Statistics
Prerequisite, Statistics 135. (3).

321, 322-Special Problems
Prerequisite, permission of the instructor. (3).

331, 332-Advanced Research
Prerequisite, permission of the instructor. (3).

393-Master's Thesis
Prerequisite, permission of the student's adviser. Fall and spring. Staff. (Var.).

394-Doctoral Dissertation
Prerequisite, permission of the student's adviser. Fall and spring. Staff.(Var.).

400-General Registration

The following 300-level courses have been offered in recent years and are likely to be offered again in the future.

Applied Statistics
This course provides a wide spectrum of commonly used data analysis techniques and some necessary theory for these techniques. It covers the basic theory of linear models and survival analysis. Topics covered include generalized linear models, logistic regression, log-linear models, maximum likelihood methods, model diagnostics, smoothing techniques, estimation of survival functions, proportional hazards models, and censored regression. Fan.

Statistical Computing
An introduction to aspects of numerical computing and graphics relevant to statistical application. Computing machine architecture and arithmetic, basic computational techniques, error propagation. Specific numerical techniques such as linear algebra, root finding, optimization, quadrature. No prior computing experience is required but the course includes practical exercises in a high-level language. Marron.

Close-Up

Dissertation Research

Statistical Consulting
Researchers from other departments present talks on current problems for which they need help with modeling and/or data analysis. Students and faculty discuss the statistical aspects of the problems and potential methods of solution. Each problem is then assigned to one or two students who consult further with the client. A written report is prepared for the client by the students and is evaluated by the instructor. Previous problems have included estimating the rate of emissions of subatomic particles by the sun, modeling the flow of various types of orders at a photocopying store, analyzing reactions to television commercials (curves as data), and evaluating methods of determining a person's percent of body fat. Fan, Marron, R. Smith.

Asymptotic Statistics
This course covers the following topics: Hellinger distance, contiguity and local asymptotic normality; convergence rates for estimators; Hoeffding's decomposition; resampling (jackknife and bootstrap). Van Zwet.

Design and Statistical Procedures For Industrial Experimentation and Clinical Trials
This course is in two parts. (I) Quality assurance of industrial products. Factorial and fractional factorial designs, orthogonal and balanced arrays, screening of factors, mixture designs, empirical model and response surfaces. The Taguchi approach, case studies. (II) Controlled clinical trials. Principles and prerequisites of clinical trials, protocols, randomized controlled trials, blindings and placebos, crossover designs, adaptive and sequential designs. Statistical analysis, monitoring of trials, cooperative studies, and interpretation of findings. Chakravarti.

Gibbs Random Fields and Certain Statistical Applications
The course is centered on the concept of Gibbs states as a generalization of Markov chains, from its physical origins in statistical mechanics to modern statistical application in image processing. Fundamentals: existence and uniqueness of Gibbs states, mixing properties, phase transition. Limit theorems: the variational principle and Shannon-McMillan-Breiman theorem, central limit theorems, large deviations. Applications in image processing: stochastic relaxation, iterated conditional modes, parameter estimation. Ji.

Topics in Weak Convergence, Markov Processes and Stochastic Differential Equations
Weak convergence of probability measures: the Prokhorov theory, weak convergence in C[0,1] and D[0,1]. Markov processes: transition functions and semigroups, infinitesimal generators, diffusion processes, and the Kolmogorov equations. Stochastic differential equations: semimartingales and Ito's formula, strong and weak solutions of one-dimensional SDE's, existence and uniqueness, Brownian motion, the Ornstein-Uhlenbeck process, more general diffusion equations. Applications in statistics, physics, and biology. Kallianpur.

For a complete list see *Record of The University of North Carolina at Chapel Hill, The Graduate School.* Names represent recent and anticipated instructors of the listed courses.

Faculty

Charles R. Baker
Professor Emeritus
B.S. (1957), University of Southwestern Louisiana; M.S. (1963), Ph.D. (1967), University of California at Los Angeles.

Positions: Land-Air (1957–9); Bendix (1959–68); UNC–Chapel Hill (1968–).

Baker's major research interests are in applications of stochastic processes and functional analysis to infinite-dimensional problems in information theory and the detection and classification of signals embedded in noise. He also is interested in development of algorithms.

Selected Recent Publications:
Capacity of dimension-limited channels, *J. Multiv. Anal.*, 37 (1991), 239–58.

Information capacity of the stationary Gaussian channel (with S. Ihara), *IEEE Trans. Inform. Theory*, 37 (1991), 1314–26.

Absolute continuity and mutual information for Gaussian mixtures (with A.F. Gualtierotti), *Stochastics & Stochastics Rep.*, 39 (1992), 139–57.

Stamatis Cambanis
Professor
B.S. (1966), National Technical University, Athens, Greece; Ph.D. (1969), Princeton University.

Faculty Positions: UNC–Chapel Hill (1969–).
Honorary Doctorate, University of Athens, Greece (1987); Fellow, IMS; Fellow, IEEE; Member, ISI.

Cambanis is interested in a wide range of problems involving stochastic processes that arise in the statistical theory of communication and the analysis of random signals and systems. In recent years his research has concentrated on the development of non-Gaussian models and on digital processing of random signals.

The goal in the first area is to develop signal processing techniques and statistical inference in non-Gaussian environments, including stable and other infinitely divisible models, with particular emphasis on the similarities and contrasts between the well-

understood Gaussian and newly explored non-Gaussian models.

The second area includes issues such as sampling designs for various statistical estimation problems involving time series and random fields; signal quantization; Monte Carlo integration; and the multiresolution decomposition of random processes via wavelets.

Selected Recent Publications:
Stable mixed moving averages (with D. Surgailis, J. Rosinski, and V. Mandrekar), *Probab. Th. Rel. Fields*, 97 (1993), 543–58.

On stable Markov processes (with R.J. Adler and G. Samorodnitsky), *Stoch. Proc. Appl.*, 34 (1990), 1–17.

Sampling designs for estimating integrals of stochastic processes (with K. Benhenni), *Ann. Statist.*, 20 (1992), 161–94.

Edward Carlstein

Associate Professor
B.Sc. (1979), Cornell University; M.A. (1980), M.Ph. (1983), Ph.D. (1984), Yale University.

Faculty Positions: UNC–Chapel Hill (1984–).

Carlstein's main research interests are in methods of nonparametric statistical inference, that is, methods which do not require the user to know what particular distribution or model produced the data at hand. Such methods are needed when the statistician lacks prior knowledge of the underlying data-generating process, or when the statistician wants a robust corroborator for results from a parametric analysis of the data. He is especially interested in nonparametric estimation of change-points and boundaries, and of sampling distributions (via resampling). A change-point is the time at which observations in a sequence cease to arise from the "old" distribution and begin to arise from a "new" distribution; nonparametric estimation of change-points is important in quality control and in epidemiology. When observations are on a grid, as in image analysis or geological data, a boundary may partition the observations into homogeneous groups; this boundary can be estimated nonparametrically using methods analogous to the change-point estimators.

In order to make statistical inferences, one needs information about the sampling distribution of the statistic at hand. Although in many situations the sampling distribution is known to be approximately normal, there are many other cases where the sampling distribution cannot be derived theoretically and may be quite non-normal, for example if the statistic is extremely complicated or if the observations are not independent. Resampling methods, such as the jackknife and the bootstrap, allow the statistician to nonparametrically estimate sampling distributions in these difficult situations, essentially by reusing the observed data.

Selected Recent Publications:
Nonparametric change-point estimation, *Ann. Statist.*, 16 (1988), 188–97.

Boundary estimation (with C. Krishnamoorthy), *J. Amer. Statist. Assoc.*, 87 (1992), 430–38.

Nonparametric estimation of the moments of a general statistic computed from spatial data (with M. Sherman), *J. Amer. Statist. Assoc.*, 89 (1994), no. 426, (to appear).

Indra M. Chakravarti

Professor
B.Sc. (1948), M.Sc. (1950), Ph.D. (1958), Calcutta University.

Faculty Positions: UNC–Chapel Hill (1959–60, 1961–2, 1964–); Case Institute of Technology (1960–1); University of Geneva, Switzerland (1961–4); Indian Statistical Institute (1951–9).
Fellow, IMS; Member, ISI. Médaille des Sociétés de Statistique de Paris et de France.

The mainstream of Chakravarti's research is combinatorial, statistical and computational problems that arise in design theory, structure and analysis of designed experiments with proper randomization, nearest neighbor models and other models of dependence and optimal designs, and on problems of error-free and secure communication in information and coding theory. Design theory and coding theory share much in common—many designs coexist with certain codes and often the mathematics (group theory, algebra, finite geometry, number theory, and algebraic geometry) used in both theories are similar.

There is a demand for innovative research in design theory because high-tech systems and industries require efficient designs for experiments for quality products at low cost and for empirical modeling of complex systems by simulation. This also applies to the needs of medical and pharmaceutical research for designs for clinical trials and procedures. In coding theory, for example, efficient codes and successful implementation of such coding and decoding procedures are needed for sophisticated complex multi-access communication systems.

This shared interest in multiple disciplines is the key to a vast pool of exciting and challenging research problems that call for combinatorial, statistical and computational research skills for their solution.

Selected Recent Publications:
Block designs for first and second order neighbor correlations (with J.P. Morgan), *Ann. Statist.*, 16 (1988), 1206–24.

Families of codes with few distinct weights from singular and nonsingular Hermitian varieties and quadrics in projective geometries and Hadamard difference sets and designs associated with two-weight codes, in *Coding*

Theory and Design Theory, Part I Coding Theory (D. Ray-Chaudhuri, ed.), Institute of Mathematics and its Applications, 20 (1990), 35–50.

Geometric construction of some families of two- and three-class association schemes and codes from nondegenerate and degenerate Hermitian varieties, *Discrete Mathematics*, 111 (1993), 95–103.

Jianqing Fan

Assistant Professor

B.S. (1982), Fudan University, Shanghai, China; M.A. (1985), Academia Sinica, Beijing, China; Ph.D. (1989), University of California at Berkeley.

Faculty Positions: UNC–Chapel Hill (1989–).
Evelyn Fix Memorial Medal, University of California at Berkeley,
NSF Postdoctoral Fellowship, 1993–6.

Fan is interested in nonparametric function estimation, errors in variables and deconvolution, generalized linear models, survival analysis, nonlinear time series, wavelets and their applications, nonparametric tests, statistical decision theory, and statistical computing. His primary research focuses on developing and justifying statistical methodology. This is expanded into other scientific areas where the statistics discipline is useful.

In each of the areas mentioned above, Fan devotes most of his efforts to the search for intuitively appealing, model-free, robust nonparametric approaches and illustrates the approaches by real data and simulated examples. Modern statistical principles and modeling inevitably involve intensive computation, which is a part of the methodological research development. He is also very interested in developing an understanding of the philosophy behind statistical theory and in providing some fundamental understanding to sophisticated statistical models. These include distributional theory, asymptotic minimax theory, efficient semiparametric modeling, and nonlinear function estimation.

Selected Recent Publications:

Local linear regression smoothers and their minimax efficiency, *Ann. Statist.*, 21 (1993), 196–216.

Nonparametric regression with errors-in-variables (with Y.K. Truong), *Ann. Statist.*, 21 (1993), 1900–25.

Censored regression: nonparametric techniques and their applications (with I. Gijbels), *J. Amer. Statist. Assoc.*, 89 (1994), 560–70.

A. Ronald Gallant

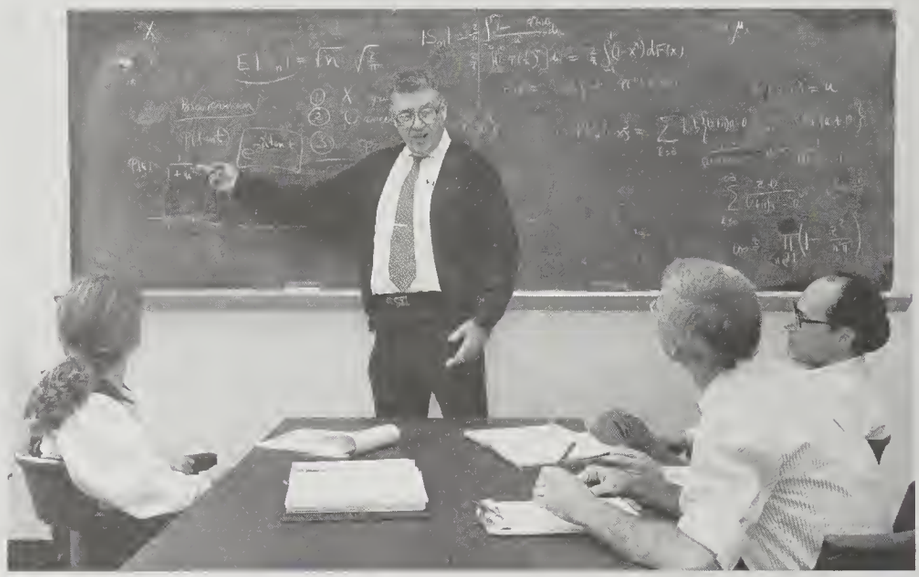
Henry A. Latané Professor of Economics and Adjunct Professor of Statistics

A.B. (1965), San Diego State University; M.B.A. (1967), University of California at Los Angeles; Ph.D. (1971), Iowa State University.

Faculty Positions: North Carolina State University (1971–93), UNC–Chapel Hill (1993–).
Fellow, ASA; Fellow, Econometric Society.

Gallant is interested in fitting models from the sciences to data for the purpose of statistical inference. Typically, these models will involve a nonlinear parametric component that describes features of the model where the underlying scientific theory is explicit, and a nonparametric component that accounts for features where the scientific theory is vague. Appropriate statistical methods for these problems are usually computationally intensive. The methodological interest is developing statistical methods and numerical algorithms for fitting these models. The theoretical interest is deriving the statistical properties of proposed methods, particularly the asymptotic properties of estimators of functionals of the nonparametric component. Applied interest is primarily within economics and finance.

Close-Up



1993 Hotelling Lecturer Larry Shepp

Selected Recent Publications:
Stock prices and volume (with P.E. Rossi and G.E. Tauchen), *Rev. Finan. Studies*, 5 (1992), 199–242.

The nonlinear mixed effects model with a smooth random effects density (with M. Davidian), *Biometrika*, 80 (1993), 475–88.

Convergence rates for single hidden layer feedforward networks (with D.F. McCaffrey), *Neural Networks*, 7 (1993), 147–58.

Harry L. Hurd

Adjunct Professor
B.S. (1963), M.S. (1964), University of Kentucky; Ph.D. (1970), Duke University

Positions: Bell Telephone Laboratories (1964–76); Xybion Corporation (1976–83); Harry L. Hurd Associates (1983–); UNC–Chapel Hill (1994–).

Hurd's primary interest is nonstationary random processes with emphasis on the periodically and almost periodically correlated processes. Processes with this structure typically appear whenever systems that would otherwise generate stationary random processes are perturbed periodically with respect to time. Natural examples occur in meteorology, mechanical systems, and in many animal "calls" including voiced human speech.

His theoretical interests include Fourier theory of the correlation; the role of unitary operators and process representation; harmonizable processes; nonstationary random fields; prediction theory; generalized harmonic analysis; periodically perturbed dynamical systems.

Hurd's application-oriented interests are primarily focused on issues of time-series analysis for the aforementioned nonstationary processes. These include estimation of the family of coefficient functions describing the correlation; estimation of the corresponding spectral densities; testing a time series for the presence of periodic correlation; statistical inference in the presence of nonstationary measurement errors; modeling by parametric systems (such as ARMA) with periodically time-varying coefficients.

Selected Recent Publications:
Periodically correlated and periodically unitary processes and their relationship to L2[0,T]-valued stationary sequences (with G. Kallianpur), in *Nonstationary Stochastic Processes and Their Application* (J.C. Hardin and A.G. Miamee, eds.), World Scientific Publishing (1992).

Periodic correlation in stratospheric ozone time series (with P. Bloomfield and R. Lund), *J. Time Series Anal.*, 15 (1994), no. 2, (to appear).

Laws of large numbers for periodically and almost periodically correlated processes (with S. Cambanis, C. Houdre and J. Leskow), *Stoch. Proc. Appl.* (1994), (to appear).

Chuanshu Ji

Assistant Professor
B.S. (1981), M.A. (1982), Tsinghua University, China; M.Ph. (1986), Ph.D. (1988), Columbia University.

Faculty Positions: UNC–Chapel Hill (joint with Mathematics), (1988–).

Ji's research interests include statistical image analysis, random fields, stochastic geometry, and chaotic time series. These concern the interface of statistics and other areas such as image analysis, neural networks, and chaotic dynamical systems. These fields generate a great deal of interesting and challenging statistical problems that go beyond the scope of traditional statistics. Statisticians can contribute to various aspects: modeling, inference, and computing. For instance, Ji's work in image analysis involves fitting probability models by observed digital pictures in order to produce synthetic images to test procedures for image restoration, segmentation, and enhancement. Statisticians need a good understanding of the geometric structure and an effective summary of the characteristics of real images. The

Close-Up

Lectures, Lectures, Lectures!

proposed image models based on random fields and stochastic geometry have a strong theoretic flavor. On the other hand, implementation of these proposals is closely tied with real applications in computer vision.

Selected Recent Publications:
Estimating functionals of one-dimensional Gibbs states, *Probab. Th. Rel. Fields*, 82 (1989), 155–75.

Sieve estimators for pair-interaction potentials and local characteristics in Gibbs random fields, *Ann. Statist.*, (1994), (to appear).

A consistent model selection procedure for Markov random fields based on penalized pseudo-likelihood (with L. Seymour), submitted to *Ann. Appl. Probab.*

Norman L. Johnson

Alumni Distinguished Professor Emeritus
B.Sc. (1936), B.Sc. (1937), M.Sc. (1938), Ph.D. (1948), D.Sc. (1963), University College, London.

Positions: University College, London (1938–9, 1945–62); London Ordnance Board (1939–45); UNC–Chapel Hill (1962–).
Fellow, Institute of Actuaries (London); Fellow, ASA, Shewhart Medal, American Society for Quality Control, Wilks Award, American Statistical Association.

Johnson's major interests are in distribution theory and applications of statistical methods in industrial experimentation, quality assurance, and actuarial investigations.

Selected Recent Publications:
Encyclopedia of Statistical Sciences (with S. Kotz and C.B. Read), 10 vols., (1982–9), Wiley, New York.

Process Capability Indices (with S. Kotz), Chapman and Hall, London (1993).

Univariate Discrete Distributions (with S. Kotz and A.W. Kemp), Wiley, New York (1993).

Gopinath Kallianpur

Alumni Distinguished Professor
B.A. (1945), M.A. (1946), University of Madras; Ph.D. (1951), UNC–Chapel Hill.

Faculty Positions: University of California, Berkeley (1951–2); Institute of Advanced Study, Princeton (1952–3); Indian Statistical Institute (1953–6); Michigan State University (1956–9, 1961–3); Indiana University (1959–61); University of Minnesota (1963–76); Director, Indian Statistical Institute (1976–9); UNC–Chapel Hill (1979–).
Fellow, Indian Academy of Sciences; Fellow, IMS; Member, ISI.

Kallianpur's current research is in four areas: (1) A new approach to nonlinear filtering and prediction theory, based on white noise calculus, has been developed in conjunction with R.L. Karandikar. Further ramifications and a possible extension are being considered; (2) Stochastic differential equations whose solutions take values in duals of nuclear spaces are being investigated. Such equations arise when stochastic partial differential equations do not have regular solutions and also in various applications in neurophysiology, environmental pollution, and certain problems of applied mathematics; (3) Another actively developing area is concerned with chaos expansions, stochastic integrals and infinite dimensional calculus. This deals with a number of important topics, including the Stratonovich form of multiple Wiener integrals, application to the Feynman integral and to anticipative stochastic integration; and (4) The time domain and spectral theory of two parameter stationary random fields is being developed jointly with V. Mandrekar with a view to applications in texture analysis and image processing.

Selected Recent Publications:
White Noise Theory of Prediction, Filtering and Smoothing (with R.L. Karandikar), Gordon and Breach, London, (1988).

Diffusion equations in duals of nuclear spaces (with I. Mitoma and R. Wolpert), *Stochastics*, 29 (1990), 285–329.

Homogeneous chaos, p-forms, scaling and the Feynman integral (with G.W. Johnson), *Trans. Amer. Math. Soc.*, 340 (1993), 503–48.

Alan F. Karr

Professor (joint with Biostatistics) and Associate Director, National Institute of Statistical Sciences
B.S. (1969), M.S. (1970), Ph.D. (1973), Northwestern University.

Positions: Johns Hopkins University (1973–92); National Institute of Statistical Sciences (1992–), UNC–Chapel Hill (1993–).

Karr's research is in statistical inference for stochastic processes, especially point processes, and in applications of statistics and probability in the engineering and physical sciences.

As Associate Director of NISS, Karr develops and manages large, cross-disciplinary research projects involving statistics and addressing issues of national and global importance, among which are environmental monitoring, materials processing and design, transportation, development of large software systems, and environmental equity.

Selected Recent Publications:
Nonparametric survival analysis with time-dependent covariate effects: A penalized partial likelihood approach (with D.M. Zucker), *Ann. Statist.*, 18 (1990), 329–53.

Probability, Springer-Verlag (1993).

Statistics and Materials Science: Report of a Workshop, National Institute of Statistical Sciences, Tech. Rpt. #4, January 1994.

Douglas G. Kelly

Professor

A.B. (1961), Princeton University; M.S. (1964), Ph.D. (1967), Indiana University

Faculty Positions: UNC–Chapel Hill (joint with Mathematics), (1968–).

Kelly's research has been in three areas. First in combinatorial mathematics, including matroid theory and the Ising and related problems; then in applications of combinatorial and geometric probability to the study of algorithms; and most recently, mathematical modeling and data analysis in neurophysiology.

Selected Recent Publications:

Minicolumnar organization of SI segregates, Cerebral Cortex (1994), to appear.

Stability in contractive nonlinear neural networks, *IEEE Trans. Biomed. Eng.*, 37 (1990), 231–42.

Introduction to Probability. MacMillan, 1994.

M. Ross Leadbetter

Professor

B.Sc. (1953), M.Sc. (1954), University of New Zealand; B.A. (1958), M.A. (1962), University of Cambridge; Ph.D. (1963), UNC–Chapel Hill.

Positions: New Zealand Applied Mathematics Laboratory, Wellington (1955–6); Naval Research Laboratory, Auckland (1958–60); Research Triangle Institute, North Carolina (1961–6); UNC–Chapel Hill (1966–).
Honorary Doctorate, Lund University; Fellow, ASA; Fellow, IMS; Member, IMS Council; Member, ISI.

Leadbetter's research interests are in probability and statistics, stochastic processes, extremal theory and statistical communication theory; engineering, oceanographic, and environmental applications.

Selected Recent Publications:

Limit theorems for strongly mixing stationary random measures (with T. Hsing), *Stoch. Proc. Appl.*, 36 (1990), 231–43.

On a basis for 'Peaks over Threshold' modeling, *Statist. Probab. Letters*, 12 (1991), 357–62.

On high level exceedance modeling and tail inference, *J. Statist. Planning and Inference* (1994), (to appear).

Barry Margolin

Adjunct Professor and Chairman, Department of Biostatistics

B.S. (1963), City College of New York; M.A. (1964), Ph.D. (1967), Harvard University.

Positions: Yale University (1967–77); National Institute of Environmental Health Sciences, RTP, (1978–87); Department of Biostatistics, UNC–Chapel Hill, (1987–).
Fellow, ASA; George W. Snedecor Award of the ASA; NIH Director's Award; W.J. Youden Award of the ASA.

Margolin has conducted research and published extensively on statistical methodology, particularly in the area of design and analysis of experiments. In the last decade he has also published a substantial number of papers on quantitative issues in genetic toxicology. He is the coeditor of two books summarizing the results of two international collaborative studies conducted by the World Health Organization to assess the performance of in vitro and in vivo genotoxicology assays as predictors of rodent carcinogenicity.

Selected Recent Publications:

Methodologic issues in epidemiologic studies using biomarkers (with B.S. Hulka), *Amer. J. Epidem.*, 135 (1992), 200–209.

Testing goodness of fit of a multinomial model against overdispersed alternatives (with B.S. Kim), *Biometrics*, 48 (1992), 711–19.

V3 loop of the human immunodeficiency virsu type 1 env protein: Interpreting sequence variability (with L. Milich and R. Swanstrom), *J. Virology*, 67, (1993), no. 9, 5623–34.

J. Stephen Marron

Professor

B.S. (1977), University of California, Davis; Ph.D. (1982), University of California, Los Angeles.

Faculty Positions: UNC–Chapel Hill (1982–).
Fellow, IMS.

Marron's theoretical interest is in smoothing methods for curve estimation. This is a flexible and powerful approach to data analysis, especially useful in situations where a good parametric model is unknown or where there is a need for visual model checking. Mathematical analysis, especially a wide array of asymptotics to the depth of minimax lower bounds, is a frequently used methodological research tool in this area. However, computational, numerical and graphical methods are also indispensable. These techniques are broadly applicable in most areas of science where numbers and uncertainty are involved. Applications have been in biology, economics, geology, image analysis, and marketing.

Selected Recent Publications:

A simple root n bandwidth selector (with M.C. Jones and B.U. Park), *Ann. Statist.*, 19 (1991), 1919–32.
Choosing a kernel regression estimator (with discussion). With C.K. Chu. *Statist. Sci.*, 6 (1992), 404–36.

Regression smoothing parameters that are not far from their optimum (with W. Härdle and P. Hall), *J. Amer. Statist. Assoc.*, 87 (1992), 227–33.

Andrew Nobel

Assistant Professor

B.S.E.E. (1985), Cornell University; Ph.D. (1992), Stanford University.
Churchill Scholar, Cambridge University, England, 1985–6.

Positions: Fellow, Beckman Institute for Advanced Science and Technology, University of Illinois (1992–5); UNC Chapel Hill (1994–).

Nobel's research falls in the area of nonparametric statistics and pattern recognition. During the past several years his research has concentrated on uniform laws of large numbers and on the statistical properties of Lossy data-compression schemes. Schemes of particular interest are those based on nearest neighbor or tree-structured clustering of multivariate data. These are a widely used means of compressing medical images and sampled speech.

More recently Nobel has been investigating the consistency of greedy growing algorithms for tree-structured classification and regression rules. Given a sequence of labeled training vectors, these algorithms produce a classification (or regression) tree one node at a time in a stepwise optimal fashion. Analysis of such greedy algorithms is based on recent results concerning histogram classification and regression estimation using data-dependent partitions.

Future research will include rates of convergence for tree-structured methods, approximation theoretic issues related to tree-structured clustering, and a systematic analysis of pruning.

Selected Recent Publications:

A note on uniform laws of averages for dependent processes (with A. Dembo), *Statist. Probab. Letters*, 17 (1993), 169–72.

Histogram regression estimation using data-dependent partitions (submitted for publication).

Termination with continuity of greedy growing for tree-structured vector quantizers (with R. Olshen), (submitted for publication).

Robert N. Rodriguez

Adjunct Professor

B.Sc. (1972), Case Institute of Technology; M.S. (1976), Ph.D. (1977), UNC–Chapel Hill.

Positions: General Motors Research Laboratories (1977–83); SAS Institute (1983–); UNC–Chapel Hill (1986–).

At SAS Institute Rodriguez is head of software research and development groups in the areas of linear models and statistical quality improvement. His own interests include real-time process control, statistical process control, statistical graphics, and distribution theory and modeling.

Selected Recent Publications:

Statistical effects of imperfect inspection sampling: IV. Modified Dorfman screening procedures (with N.L. Johnson and S. Kotz), *J. Quality Tech.*, 22 (1990), 128–38.

New developments in process capability analysis. *J. Quality Tech.*, 24 (1992), 176–87.

Computation of Owen's Q function applied to process capability analysis (with G.H. Guirguis), *J. Quality Tech.*, 24 (1992), 236–46.

Pranab K. Sen

Professor and Cary C. Boshamer Professor of Biostatistics

B.Sc. (1955), M.Sc. (1957), Ph.D. (1962), Calcutta University.

Faculty Positions: Calcutta University (1961–4); University of California, Berkeley (1964–5); UNC–Chapel Hill (Biostatistics), (1965–). Fellow, IMS; Fellow, ASA; Member, ISI.

Sen has research interests in three areas. His theoretical and methodological research interests are nonparametrics with special emphasis on multivariate nonparametric methods and sequential nonparametrics; robustness of statistical procedures in linear models; sequential estimation; decision theoretic problems in statistical inference; Pitman measure of closeness of estimators; survival analysis; asymptotic methods.

His application-oriented research interests include statistical bioassays, longitudinal studies and growth curve models; clinical trials and time-sequential analysis; resampling methods with special emphasis on jackknifing and bootstrapping.

His interests in purely applied research include statistical considerations in arteriosclerosis problems, Reye's Syndrome, genotoxicity, and environmental statistics.

Selected Recent Publications:

Cox regression model with time-dependent covariates (with S.A. Murphy), *Stoch. Proc. Appl.*, 39 (1991), 153–80.

On Hadamard differentiability of extended statistical functionals (with J.J. Ren), *J. Multiv. Anal.*, 39 (1991), 30–43.

Statistical perspectives in clinical and health sciences: The broadway to modern applied statistics, *J. Appl. Statist. Sc.*, 1 (1993), 1–50.

Gordon D. Simons

Professor and Chair

B.A. (1960), M.A. (1964), Ph.D. (1966), University of Minnesota.

Faculty positions: Stanford University (1966–8); UNC–Chapel Hill (1968–).
Fellow, IMS; Member, ISI.

Simons' interests are statistical inference and applied probability. Recently he and some graduate students worked on a sequential statistical model for conducting clinical trials with the express purpose of increasing the number of patients who receive the best treatment during and after the testing phase of the trials. Another area of interest is a collection of inferential questions associated with "binary symmetric channels," a topic in a semiparametric context with relevance to coding and imaging. These projects include a challenging mixture of mathematics and numerical computations.

A project of mostly theoretical interest has been an effort to unify some old work of J. L. Doob's concerned with the preservation of iid random variables under a sequence of stopping times; and some recent work by Ignatov, of a very different sort, concerned with the distributions of record values. A current project is the writing of a monograph with Sándor Csörgő on the "St. Petersburg Paradox," a fascinating problem that engaged the interest of almost every leading thinker of mathematical note in the eighteenth century, and which, according to economist and Nobel laureate Paul Samuelson, "enjoys an honored corner in the memory bank of the cultured and analytic mind." Beyond its concern with the historical side of the subject, the monograph will attempt to resolve the paradox through the inclusion of recent unpublished probabilistic research, some of which is still in progress.

Selected Recent Publications:
Estimating distortion in a binary symmetric channel consistently, *IEEE Trans. Inform.Theory*, 37 (1991), 1466–70.

On a problem of ammunition rationing (with L. Shepp and Y-C Yao), *Adv. Appl. Probab.*, 23 (1991), 624–41.

On Steinhaus' resolution of the St. Petersburg paradox (with S. Csörgo), *Probab. and Math. Statist.* (1994), (to appear).

Richard L. Smith

Professor
B.A. (1975), Oxford University; Ph.D., (1979), Cornell University.

Faculty Positions: Imperial College (1979–85); University of Surrey (1985–90); UNC-Chapel Hill (1991–). Fellow, IMS; Member, ISI. Guy Medal in Silver, Royal Statistical Society. Chartered Statistician of the Royal Statistical Society.

Richard Smith has theoretical interests in a number of areas, including extreme value theory, time series analysis, asymptotic theory, and Bayesian statistics. The area in which he has done most work is extreme value theory, which is about the distributions of very large or very small values in a time series or stochastic process. This has numerous applications connected with environmental statistics and has led to a large project over the last year on the statistical assessment of trends in extreme values of urban ozone. This is part of ongoing work conducted through the National Institute of Statistical Sciences. Another recent application is connected with global climate change ("global warming"), an area in which climatologists are currently focusing much more on the distributions of temperature extremes rather than just the mean values.

Selected Recent Publications:
Statistical Analysis of Reliability Data (with M.J. Crowder, A.C. Kimber, and T.J. Sweeting), Chapman and Hall, London (1991).

Estimating dimension in noisy chaotic time series, *J. R. Statist. Soc.*, B, 54 (1992), 329–51.

Long range dependence and global warming. In *Statistics for the Environment* (V. Barnett and F. Turkman, eds.), Wiley, Chichester (1993), 141–61.

Walter L. Smith

Professor
B.A. (1947), M.A. (1951), Ph.D. (1953), University of Cambridge.

Faculty Positions: UNC–Chapel Hill (1954–6, 1958–); University of Cambridge (1956–8). Fellow, IMS; Fellow, ASA; Member, ISI. Adams Prize, University of Cambridge; Sir Winston Churchill Overseas Fellow; Guggenheim Fellow.

Walter Smith has interests in applied probability, principally with inquiries concerning queues, storage systems (reservoirs), renewal processes, and related matters; but he is also interested in theoretical matters to do with characteristic functions and central limit theorems and, most of all, with renewal processes and the related cumulative processes. Smith introduced some probability concepts that have subsequently been much studied, including: semi-Markov processes, quasi-Poisson processes, and branching processes in random environments. At present Smith is working on density versions of the central limit theorem, the asymptotic behavior of cumulative processes, and, with a graduate student, various problems to do with storage systems, particularly when subject to periodic demands and replenishment. In recent years Smith has also been involved in the development of scientific word-processing software.

Selected Recent Publications:
On transient regenerative processes (with E. Murphree), *J. Appl. Probab.*, 23 (1986), 52–70.

EXP Express, Brooks/Cole, Pacific Grove, California (1990).

On two classic theorems involving the characteristic function, in *Aspects of Uncer-*

tainty (A.F.M. Smith and P.R. Freeman, eds.), Wiley (1994), 353–66.

Willem R. van Zwet

William Newman Research Professor
B.S. (1956), M.S. (1959), Ph.D. (1964), University of Leiden.

Faculty Positions: University of Leiden (1965–); UNC–Chapel Hill (1990–). Honorary Fellow, Royal Statistical Society; Fellow, IMS; Fellow, ASA; Member, ISI; Member, Netherlands Royal Academy of Science; Member, Academia Europaea. Van Dantzig Award, Netherlands Statistical Society; Peace Medal, Charles University, Prague; Adolphe Quetelet Medal, ISI.

Van Zwet's interest in recent years has been mainly theoretical statistics. He also works in probability theory of a somewhat applied nature. Presently he is trying to develop an asymptotic theory of resampling while at the same time studying related topics in asymptotic statistics such as second-order asymptotics. Other problems of current interest concern an application of point processes in cell-biology and a purely probabilistic study of an unusual interval-splitting scheme.

Selected Recent Publications:

The Edgeworth expansion for U-statistics of degree two (with P.J. Bickel and F. Goetze), *Ann. Statist.*, 14 (1986), 1463–84.

A refinement of the KMT inequality for the uniform empirical process (with D.M. Mason), *Ann. Probab.*, 15 (1987), 871–84.

A non-Markovian model for cell population growth: Speed of convergence and central limit theorem (with M.C.M. de Gunst), *Stoch. Proc. Appl.*, 41 (1992), 297–324.

Close-Up

On Friday afternoons, volleyball!

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H. Garland Hershey Jr., D.D.S.
Vice-Chancellor for Health Affairs and Vice-Provost

Edith M. Wiggins, M.S.W.
Interim Vice-Chancellor and Dean of Student Affairs

Harold Gene Wallace, M.Div.
Vice-Chancellor, University Affairs

Henry H. Dearman, Ph.D.
Associate Provost and Dean of the Graduate School

Stephen S. Birdsall, Ph.D
Dean of the College of Arts and Sciences

About the Cover and Latin Squares

The cover image exhibits three intersecting frames as tiled 10 × 10 squares in space. The odd square has empty cells and the other two form a remarkable pair of 10 × 10 Graeco-Latin squares (or a pair of orthogonal Latin squares). These particular Graeco-Latin squares have been known only since the celebrated constructions in 1959 of all Graeco-Latin squares of order 4t + 2 (except for 6) by R.C. Bose and S.S. Shrikhande (UNC–Chapel Hill Department of Statistics) and E.T. Parker (Remington Rand, UNIVAC Minnesota). The 1959 constructions settled a serious doubt raised by L. Euler in 1782 in the context of the well-known problem of "Les 36 officiers." Can you arrange thirty-six officers drawn from six different regiments and six different ranks in a 6 × 6 square such that each rank is represented in every row and column and so also each regiment? Euler concluded that the answer was "no," although a rigorous proof was given much later, in 1900, by Gaston Terry.

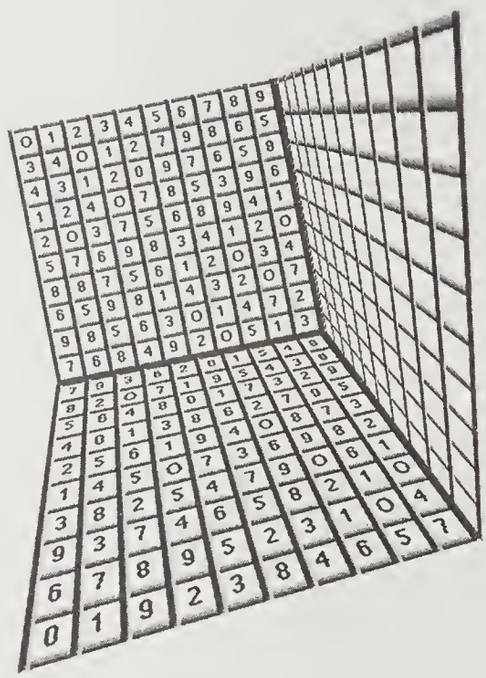
In the two squares with entries, each one of the digits 0,1,...,9 appears once in a row and once in a column. If the two squares are folded at the intersecting line, each one of the one hundred pairs 00, 01,..., 99 will appear exactly once.

The first recorded application of a Latin square as a design was in 1788 by Cretté de Palluel, who used a 4 × 4 Latin square in an animal feeding trial.

In 1926 R.A. Fisher formally introduced Latin squares as designs for agricultural experiments and provided valid statistical analysis of data based on analysis of variance techniques from such experiments. Latin squares, Graeco-Latin squares, and their relatives are now widely used as designs for scientific experiments in agriculture, industry, and clinical trials. Combinatorial arrangements based on such squares have been adapted for use as error-correcting codes for reliable transmission over noisy channels, in cryptography, and in secret sharing. They serve also as building blocks for other designs and finite geometries. There is a vast and fascinating literature on the combinatorial theory of existence, construction and enumeration of Latin squares, orthogonal Latin squares, and their generalizations and applications.

The 10 × 10 square with empty cells on the side plane represents a challenge. Can its cells be filled also with digits 0,1,...,9 such that each digit will occur once in a row and once in a column and further, so that each time the square is folded on one of its neighbors—horizontal or vertical—a pair of Graeco-Latin squares is generated? To this day the answer is not known.

The existence of a set of nine such 10 × 10 squares such that each pair is Graeco-Latin, which is equivalent to a finite projective plane with eleven points on a line, has recently been disproved (1988) by extensive computation on a supercomputer.



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